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Ingredients In The Modern Broiler Diet

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SUMMARY

Today's commercial broiler ration will produce a 3-pound bird on 25 percent less feed than was needed before World War II. Yet today's ration is only a modification of the prewar one. Several nutrients, micro-nutrients, and non-nutrients have been added to the prewar formula which greatly increases its efficiency, even though they make up only a small percentage of the total. Although these are commonly called additives, the term has been avoided in this report since no definition has proved acceptable.

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INGREDIENTS IN THE MODERN BROILER DIET

Broiler production today is one of agriculture's most efficient enterprises. Advances in management have made possible an increase of 162 percent in output per man-hour of labor during the past 20 years. New methods of disease control have decreased mortality, and breeding has produced birds which make more efficient use of modern feeds. But these advances in management, sanitation, and breeding are no more dramatic than those made in nutrition.

PREWAR vs. PRESENT-DAY RATIONS

Determination of the relative efficiencies of prewar and present-day broiler rations was part of a research project undertaken in 1954 at the United States Department of Agriculture's Research Center, Beltsville, Md.

Three groups of birds were used in these experiments. They included (1) an unimproved [1/] prewar strain of Rhode Island Reds, (2) an improved meat-type strain of New Hampshires, and (3) a New Hampshire X Silver Cornish Cross.

Each group of birds was divided into three lots and designated as Lots 1, 2, and 3. All of the birds in Lot 1 of each group were fed a ration typical of the better commercial broiler feeds available prior to World War II. Those in Lot 2 of each group were fed a ration typical of the World War II broiler feeds, and those in Lot 3 of each group were fed one typical of today's feeds. Comparison could then be made between lots and groups of birds, and between rations.

The war-time ration proved to be the least efficient because of war-time ingredient shortages. Actually, nutrition research should be congratulated that these diets performed as well as they did. Comparisons in this report are therefore confined to prewar and present-day rations.

The crossbreds fed the present-day ration reached the desired 3-pound weight 2 weeks earlier than the unimproved, prewar strain of birds fed the prewar ration. The crossbreds also required 3.78 pounds less feed per bird (Table 1). Time and feed savings were the result of advances in both breeding and nutrition.

1/ Selected for high egg production with a minimum of improvement in early growth rate.

Table 1.--Savings resulting from improvements in breeding and nutrition

Item	Time and feed required to reach 3-pound average	
	Time	Feed
	(Weeks)	(Pounds)
Prewar strain of birds [1] fed prewar ration	12	12.15
Crossbreds [2] fed present-day ration	10	8.37
Savings	2	3.78

1/ Rhode Island Reds.
2/ New Hampshire X Silver Cornish Cross.

The improved strain of New Hampshires fed the present-day ration reached the 3-pound weight 1 week earlier than the same strain of birds fed the prewar ration, and on 2.10 pounds less feed per bird (Table 2). Obviously, a large part of the improved efficiency could be credited to advances in nutrition.

Table 2.--Savings resulting from improvements in nutrition

Item	Time and feed required to reach 3-pound average	
	Time	Feed
	(Weeks)	(Pounds)
New Hampshires fed prewar ration	10	10.26
New Hampshires fed present-day ration	9	8.16
Savings	1	2.10

Despite the great difference in the efficiencies of the two rations, a list of their ingredients shows considerable similarity between them, and some marked differences (Table 3).

Table 3.--Ingredients included in prewar and present-day rations compared in Beltsville tests

Ingredients	Prewar ration	Present-day ration
	Percent	Percent
Carbohydrates		
Ground corn	39.0	49.3
Ground wheat	22.0	.0
Protein		
Soybean oil meal	.0	32.0
Meat meal	10.0	.0
Dried buttermilk	10.0	.0
Corn gluten meal	10.0	.0
Miscellaneous		
Steamed bone meal	3.0	3.0
Ground limestone	.0	1.0
Salt 1/	.5	.5
Alfalfa meal	2.5	5.0
Dried brewers' yeast	2.0	.0
Vitamin A & D oil 2/	1.0	.3
"New" Ingredients 3/		
Choline HCl	.0	.1
Folic acid	.0	1.8 gm./ton
Lard	.0	4.0
DL-methionine 4/	.0	.1
Vitamin B-12	.0	.1
Fish solubles 5/	.0	4.0
Butyl fermentation solubles 6/	.0	.6
Crystalline chlortetracycline 7/	.0	18.0 gm./ton
3-nitro, 4 hydroxyphenylarsonic acid 8/	.0	45.0 gm./ton
Total	100.0	100.0
Analysis (Calculated)		
Protein	19.6	20.6
Productive energy (calories per pound)	887.0	882.0
Fiber	3.0	4.6

1/ 96 parts NaCl; 4 parts $MnSO_4 \cdot 4H_2O$.
2/ 1,200 A; 400 D.
3/ Ingredients added to the broiler diet since World War II.
4/ Methionine is an essential amino acid.
5/ Fish solubles are added to supply the "fish factor."
6/ Butyl fermentation solubles are added to supply riboflavin.
7/ Chlortetracycline is an antibiotic.
8/ 3-nitro, 4 hydroxyphenylarsonic acid is one of the arsenicals.

The present-day ration differs mainly from the prewar one in that the newer ration (1) contains more corn; (2) obtains its protein primarily from vegetable sources; and (3) contains small quantities of several "new" ingredients.

The amount of corn in all broiler rations was increased after the development of the high-energy formula in 1948 by the Connecticut Agricultural Experiment Station. Connecticut researchers demonstrated that rations high in energy were very efficient in the production of poultry meat. Energy could be obtained from either fat or carbohydrates, but carbohydrates were, until recently, much cheaper than fats. Corn provided an inexpensive source of carbohydrate and energy, and amounts of corn in broiler rations were consequently increased.

Soybean oil meal is the primary protein source for today's broiler rations, since it is available in quantity and supplies all of the bird's protein needs when properly supplemented.

The "new" ingredients listed in Table 3 make up a very small proportion of the total mixture, but they are believed to be largely responsible for the increased efficiency of the present-day ration.

NUTRIENTS

One group of "new" ingredients can be clearly classified as nutrients. This group includes fats, amino acids, and vitamins.

Fats

Fats are a concentrated source of energy, supplying approximately 2.25 times as much energy as the same weight of carbohydrates. Fats, however, have been higher priced than carbohydrates such as corn, and little consideration was given to them as feed ingredients prior to World War II. But after the war, fat prices began to drop. Housewives began shifting to detergents, and the purchases of animal fat by soap manufacturers decreased in line with soap sales. An expanded livestock population greatly increased fat supplies. This increase in supply, coupled with a decrease in demand, resulted in reduced fat prices, and attempts were made to utilize fats in mixed feeds.

It was found that the addition of fat improved the feeding efficiency of broiler rations, made them less dusty, and enhanced their appearance, texture, and palatability. Commercial feed manufacturers began to include grease or lard in their broiler rations as soon as equipment could be designed to mix fat thoroughly with dry ingredients. Today, most commercial broiler feeds contain 4 to 5 percent fat (2 to 3 percent from other ingredients and 2 to 3 percent from added grease or lard). The practice of adding fat will probably continue so long as it is economically feasible.

Amino Acids

Methionine is one of the amino acids, or building blocks, that make up proteins. About 23 amino acids are known, 11 of which a chicken cannot synthesize in adequate quantities. Because these 11 must be supplied the bird, they are called essential amino acids. Methionine is an essential amino acid.

Most animal proteins, such as fish meal, supply all 11, and are usually more expensive than the somewhat-deficient vegetable proteins. Their inclusion in prewar rations provided a complete protein, but increased the cost of the feed.

After World War II, soybean oil meal enriched with synthetic methionine was found to be equal to fish meal in protein value, and because of its lower cost, has become the principal protein source for present-day broiler rations. Methionine is the only amino acid now being added to commercial feeds.

Lysine, another essential amino acid, may soon be produced synthetically to supplement the amino acid content of cottonseed meal.

Although cottonseed meal is deficient in lysine, large amounts of cottonseed meal have not been used in broiler rations for another reason. Raw cottonseed contains a substance called gossypol, which is toxic to chickens. As little as 0.016 percent of pure gossypol in the diet has been shown to retard growth in young chickens. Certain processing methods greatly reduce the gossypol content of the meal, and some progress has been made in breeding cotton varieties, whose seeds contain only small amounts of this toxic substance. As degossypolized cottonseed meal becomes available in quantity, and synthetic lysine is produced, it is believed that both will appear in broiler rations of the future.

Vitamins

A number of vitamins are recognized as necessary to adequate poultry nutrition. A, D, E, K, and the B-complex, which includes thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, biotin, choline, and folic acid, are all required for optimum growth. Feed ingredients, however, tend to supply most of these in adequate amounts, except vitamins A and D. These have been added to broiler rations for some time. The important vitamin additions to postwar rations are choline, folic acid, and B-12. Commercial broiler diets frequently contain added amounts of many of the vitamins in order to assure the presence of adequate quantities and to allow a "margin of safety." The need for these vitamins is not a new discovery. They are added because the ingredients formerly supplying them are no longer used. An example is the addition of riboflavin concentrate when milk and milk products are not used in the diet.

Vitamin B-12 is the latest of the B-complex to be isolated and produced commercially. For a long time it was known that chicks would not grow properly on vegetable proteins alone, even if the rations were supplemented with those amino acids the vegetable protein happened to be deficient in. But the inclusion of an animal protein seemed to correct the apparent deficiency. Accordingly, researchers referred to the quality of animal proteins that rendered them superior to vegetable proteins as the "Animal Protein Factor" or APF. Other workers, searching for the factor in liver that prevented or cured pernicious anemia, successfully isolated a cobalt-containing substance which is called B-12. Feeds containing only vegetable proteins (such as soybean oil meal enriched with methionine), but supplemented with B-12, gave growth results comparable to feeds containing animal proteins. It was therefore concluded that vitamin B-12 was the main constituent of APF. Since then the term, APF, has fallen into disuse.

But the cost of B-12, at that time, made it impractical as a poultry feed ingredient since a ton of fresh liver yielded only a few milligrams of the vitamin. Continued research revealed that the mold which produced streptomycin also produced B-12, and manufacture of the vitamin began. Today, B-12, added to an all-vegetable protein ration, provides a balanced feed at lower cost than one containing animal proteins.

Unknown Factors

Once B-12 had passed from the realm of unidentified factors, it was thought that the nutritional picture might be complete. But further research revealed that there were other unidentified factors important in animal nutrition.

Three of these are well-recognized and are called the "whey factor," the "fish factor," and the "alfalfa factor."

The "whey factor" is thought to be present in the following ingredients:

1. Dried distillers' solubles
2. Dried distillers' molasses solubles
3. Dried brewers' yeast
4. Butyl fermentation solubles
5. Dried whey products
6. Certain fermentation products

The "fish factor" is thought to be present in the following ingredients:

1. Fish meal
2. Fish solubles
3. Crab meal
4. Meat by-products
5. Liver preparations
6. Certain fermentation products

The "alfalfa factor" is thought to be present in the following ingredients:

1. Dehydrated alfalfa leaf meal
2. Grass juice concentrate
3. Dried brewers' yeast

It is believed that the presence of these factors tends to increase the rate of gain and the feed efficiency of broilers, although their exact contribution has not been determined. Most commercial poultry feeds today contain sufficient amounts of these ingredients to supply the estimated nutritive requirements of the birds.

Several other factors are believed to exist, but even less information is available about them. Recent research has revealed the presence of an inorganic factor or factors found in the ash of several different sources of unidentified factors.

NON-NUTRIENTS

Non-nutrient ingredients include the antibiotics, arsenicals, and antioxidants which appear in most commercial broiler feeds today. Non-nutrient ingredients also include surfactants, which are seldom added to broiler rations, and those pigments and hormones which are added for reasons other than growth promotion.

Antibiotics

The use of antibiotics in poultry nutrition is an outgrowth of the synthetic production of vitamin B-12. Subsequent work proved that another growth-promoting factor was present in the crude sources of B-12. When isolated it proved to be the antibiotic, chlortetracycline (aureomycin). Its beneficial effect was attributed to its ability to control inapparent or low-grade infections. When the inapparent infections were brought under control, increased growth, greater feed efficiency, and lower mortality usually followed. Similar benefits were attributed to the use of oxytetracycline (terramycin), penicillin, and bacitracin. As a result, most commercial broiler rations include minute amounts of one of the antibiotics -- or a mixture of two or more. Higher levels of antibiotics (100 to 250 grams per ton) appear to be of value in reducing mortality and restoring birds to a healthy condition during outbreaks of many diseases.

Arsenicals

Another group of compounds which are used as growth stimulants is the arsenicals. Although toxic at higher levels, they have been used as tonics for a number of years. Their inclusion in broiler rations is relatively recent, and it is thought that the manner in which they attain their beneficial effects is similar to that of the antibiotics. Some research

workers, however, doubt that arsenicals provide a growth response in addition to that given by the antibiotics.

The two commonly accepted arsenicals are arsonic acid (3-nitro, 4 hydroxyphenylarsonic acid), and arsanilic acid (para-amino-phydroxyphenylarsonic acid). Arsonic acid is usually used at 45 grams per ton and arsanilic acid at 90 grams per ton.

Antioxidants

Antioxidants, or chemical preservatives, are included in feeds to lessen the loss of fat-soluble vitamins (A, D, E, K) and to retard the rancidity of added fats. The two most commonly used antioxidants for poultry feeds are BHA (butylated hydroxyanisole), and BHT (butylated hydroxytoluene) which are used to stabilize fats. Such stabilized fats enhance retention of vitamin A in feed. In addition, BHT has been credited with the prevention of encephalomalacia or "crazy chick" disease. Either or both may be added to poultry rations in line with limitations set by the United States Food and Drug Administration and State feed control officials.

Surfactants

Surfactants or detergents, which have tended to replace soap in the household, may also stimulate growth. But few commercial broiler feeds contain surfactants, since there is little evidence that they provide growth stimulation beyond that provided by antibiotics.

Hormones

The principal hormones supplied meat birds are estrogens, or female sex hormones. The best known of these is stilbestrol, which came into use a few years ago as an implant for male birds. A small pellet placed just below the skin of the neck causes the bird to lose many of its secondary male characteristics, to increase fat deposition, and to improve market grade of the carcass. The material is now used in both pellet and paste forms. Later it was found that certain derivatives could be mixed with the feed to accomplish the same result. Broiler rations are now available which contain the derivative, dinesterol diacetate. As with antioxidants, feed manufacturers are required to comply with FDA and State feed control regulations before marketing broiler rations which contain an estrogen hormone.

EVALUATION OF "NEW" INGREDIENTS

Hundreds of tests have been run to evaluate the "new" ingredients individually. Results have varied tremendously. To a broilerman, however, the value of a specific ingredient is unimportant. But the value of a feed containing a combination of "new" ingredients is important.

Cost of the "new" ingredients put into a ton of feed is not great. While the price of some of them is high, only spoonful amounts are used. In addition, certain "new" ingredients, such as B-12 and methionine, make possible the use of lower-priced natural ingredients. As a result, the ingredient cost of the present-day ration used in the Beltsville test was actually $2.40 less a ton than the prewar one, using prices prevailing at that time.

But, to the broilerman, the cost of a ton of feed is not as important as the return that can be obtained by feeding it. A comparison of total feed cost, value of product, and the income over feed cost for the prewar and present-day rations, when fed to the same strain of chickens is presented in Table 4. Using prices prevailing at the time the tests were run, the prewar ration returned only 10 cents a bird over feed cost. The present-day ration, containing the "new" ingredients, returned 26 cents a bird over feed cost, or more than 2 1/2 times as much as the prewar ration.

Table 4.--Return from feeding prewar and present-day rations to New Hampshire broilers

Item	Prewar ration	Present-day ration
Feed cost per cwt. at Oct. 15, 1954, prices	$6.12	$6.00
Average weight of birds at 10 weeks	2.63 lb.	3.42 lb.
Value per bird at 25¢ a pound, live weight	$0.6575	$0.8725
Total feed cost per bird	.5540	.6050
Income over feed cost per bird	.1035	.2675

Prewar and present-day rations may be compared in another way. The broiler grower who buys a bag of feed is buying raw material from which meat will be manufactured. The two rations may be compared on the basis of the amount of live broiler each bag contains.

ARS results show that New Hampshire broilers required 3.52 pounds of the prewar ration to produce a pound of gain, but only 2.89 pounds of the present-day ration. Work with other strains produced similar results. When operating under management and environmental conditions comparable to those of ARS, the feeder is receiving nearly 35 pounds of live broiler in a hundred-pound bag of the present-day feed, and about 28 1/2 pounds of live broiler in a bag of the prewar ration. The 6 1/2 additional pounds of live broiler from a bag of the present-day ration, at 25¢ a pound, is equivalent to $1.65 a bag or $33.00 a ton over the prewar feed.

OUTLOOK

Despite great advances in nutritional knowledge over the past few years, researchers predict new developments that will make possible rations of even greater efficiency.

Larger amounts of energy-supplying fat will probably be added to feeds as mixing equipment is improved, and research should yield more knowledge of the relationship between energy and other nutrients in the feeds.

Even greater advances will be made in protein nutrition by supplementing natural proteins with synthetic amino acids so that the amino acid balance in the feed more nearly meets the bird's requirement. Very likely, lysine and other amino acids will be commercially synthesized.

The unknown growth factors will probably be isolated and synthetic sources discovered.

More about the beneficial effect of antibiotics and arsenicals will probably be learned, and their relation to environmental conditions ascertained.

Greater utilization of hormones is also likely.

These discoveries, combined with improved strains and continued improvement in disease control and management, should make possible the commercial growing of 3-pound broilers in less than 8 weeks, and on less than 6 pounds of feed. Three-pound broilers have already been produced at the Maryland Agricultural Experiment Station in less than 8 weeks, and on less than 5 pounds of feed. Although the ration used is not commercially practical at this time, it gives a clear indication of things to come.